



# Lunar Compositional Diversity as Observed by the LRO Diviner Lunar Radiometer

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Jet Propulsion Laboratory

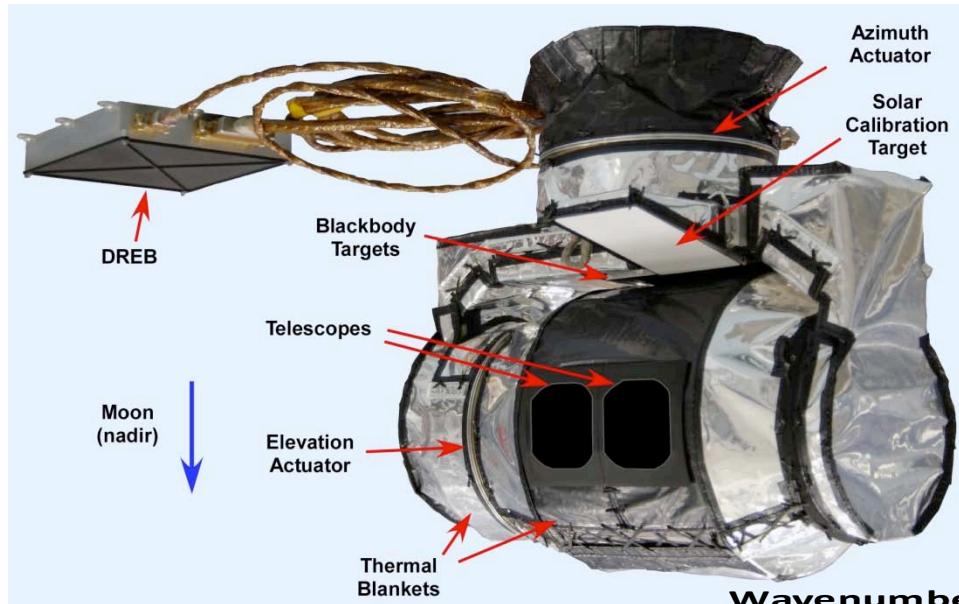
P.G. Lucey, M.B. Wyatt, T.D. Glotch, C.C. Allen, J. Arnold,  
J.L. Bandfield, N.E. Bowles, K.L. Donaldson Hanna, P.O. Hayne,  
E. Song, I.R. Thomas, and D.A. Paige

NLSI LSF 2010

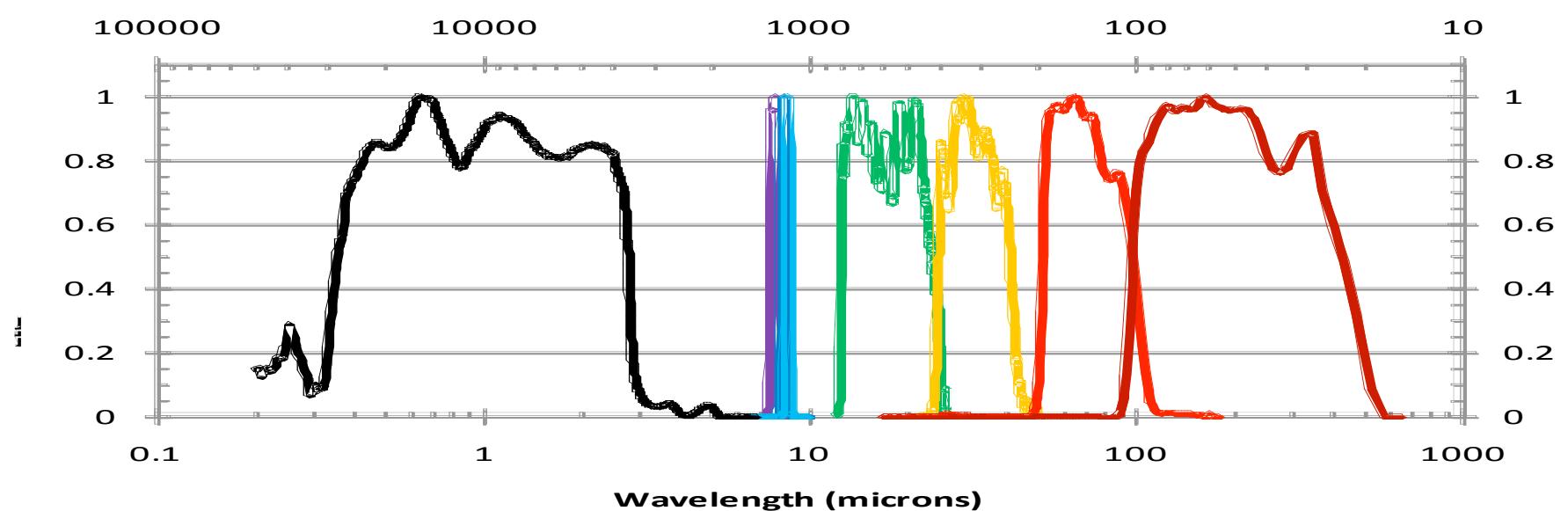
07/22/10

NASA ARC

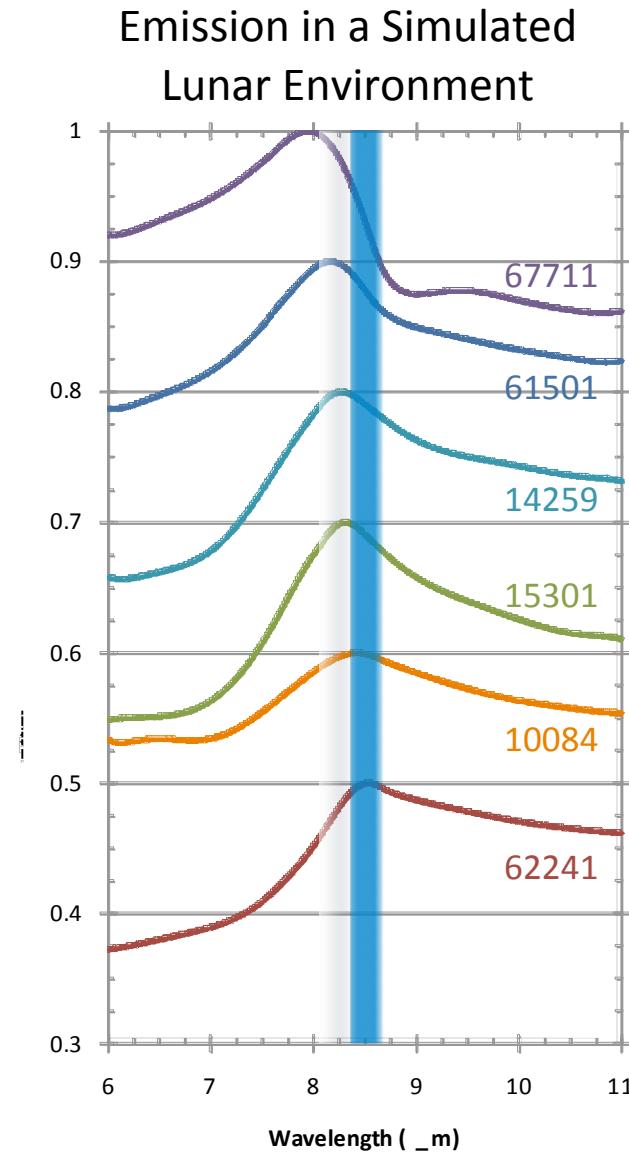
# LRO Diviner Overview



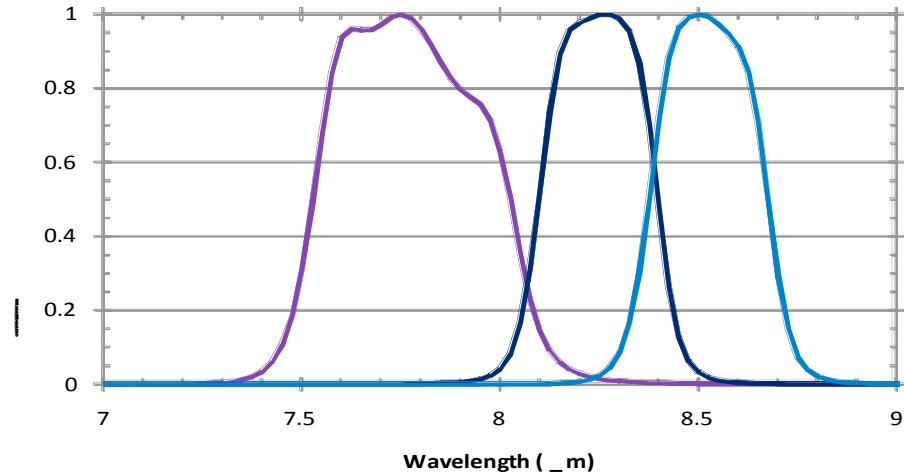
Observation Strategy	Primarily nadir pushbroom mapping
Detectors	Nine 21-element linear arrays of uncooled thermopile detectors
Fields of view	<p>Detector Geometric IFOV:</p> <ul style="list-style-type: none"> <li>6.7 mrad in-track</li> <li>3.4 mrad cross track</li> <li>320 m on ground in track for 50 km altitude</li> <li>160 m on ground cross track for 50 km altitude</li> </ul> <p>Swath Width (Center to center of extreme pixels):</p> <ul style="list-style-type: none"> <li>67 mrad; 3.4 km on ground for 50 km altitude</li> </ul>



# 8- $\mu$ m Channel Compositional Data

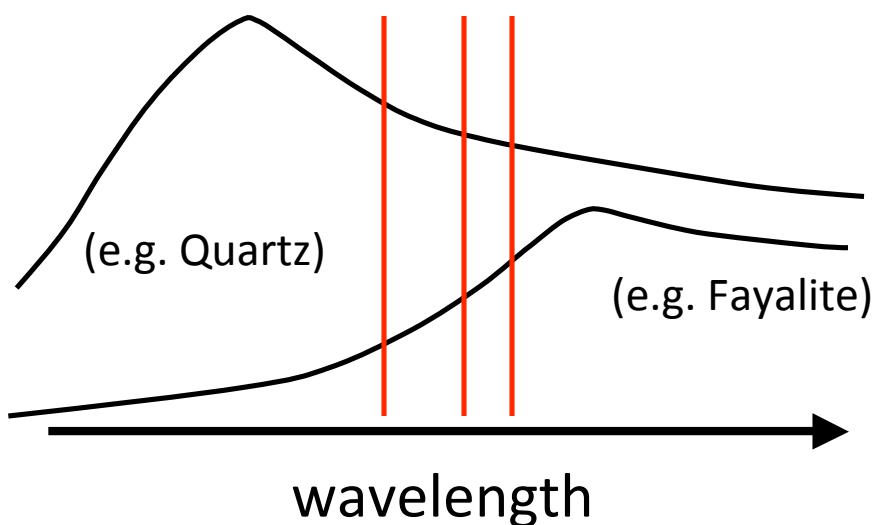
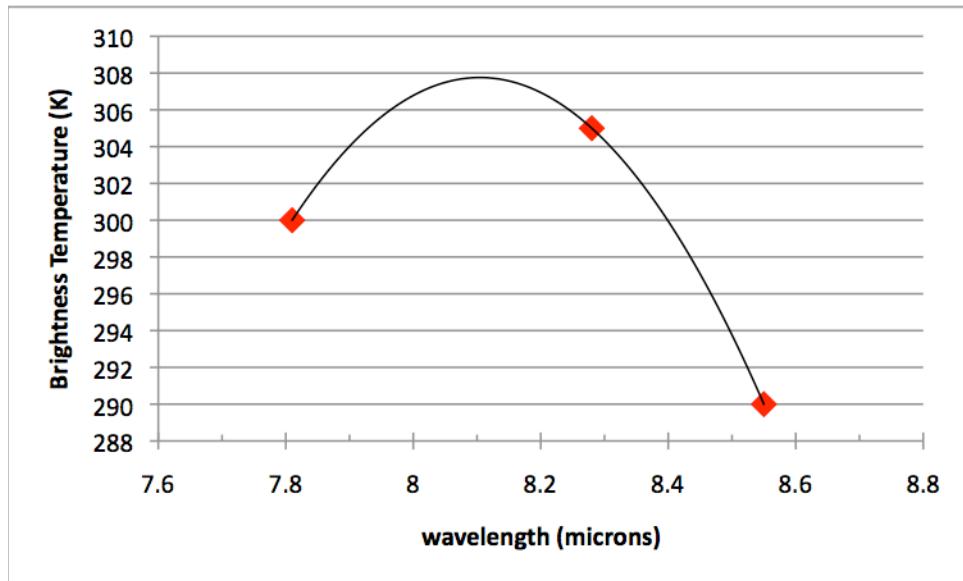


- Lunar surface emission differs from most laboratory measurements
  - Vacuum induced thermal gradients
  - Soil complexities
  - Temperature/anisothermality
- Result: Strong CF and weak Reststrahlen bands
- Diviner was designed to measure the CF of most lunar soils

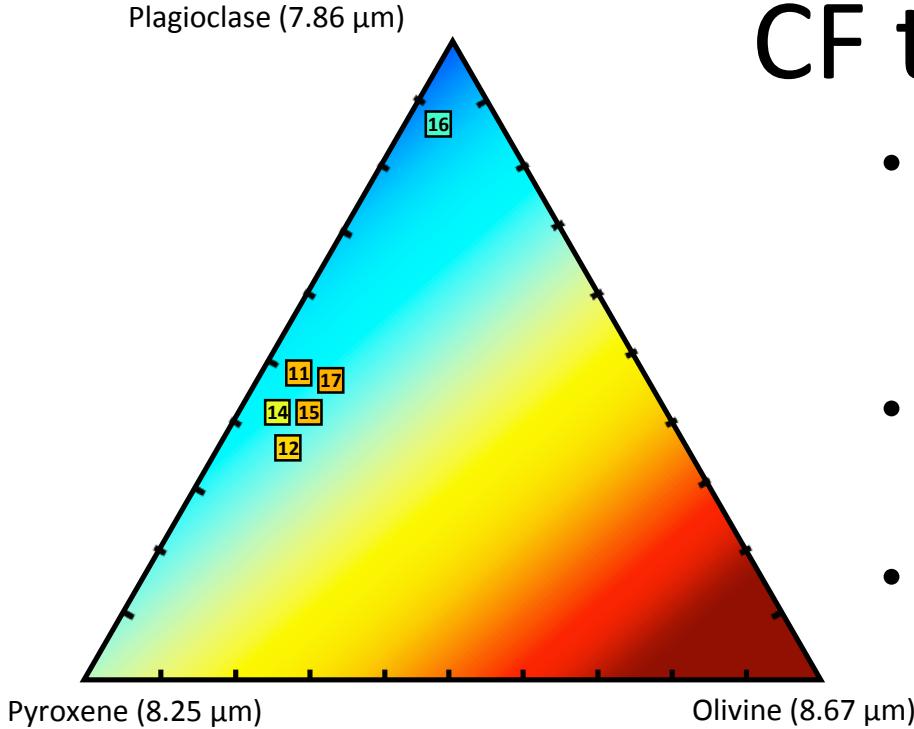


Spectra digitized from Salisbury et al., 1973

# Finding CF Positions / Values

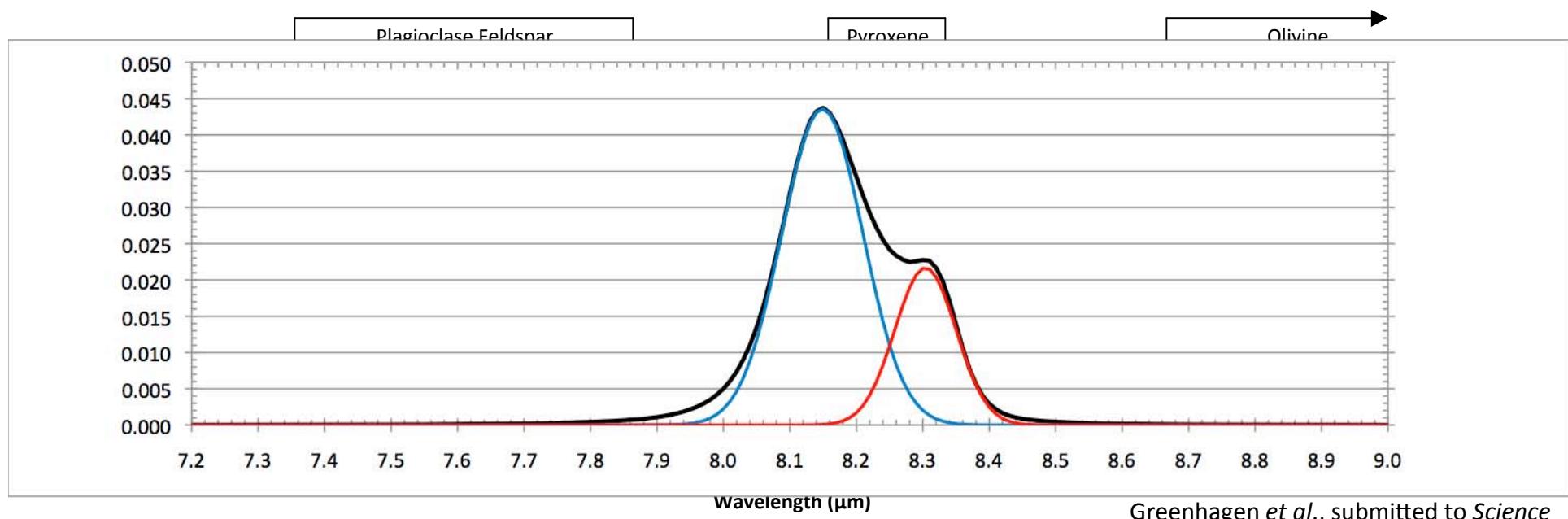


- Three points around a parabolic spectral feature?
- Simultaneously solve three quadratic equations:
  - $CF_{pos} = -B / (2*A)$
  - $CF_{val} = C - B^2 / (4*A)$
- Anomalous short or long CF positions result in concave up spectra
  - Can't find CF position
  - Can tell if the material is silica-rich or olivine-rich



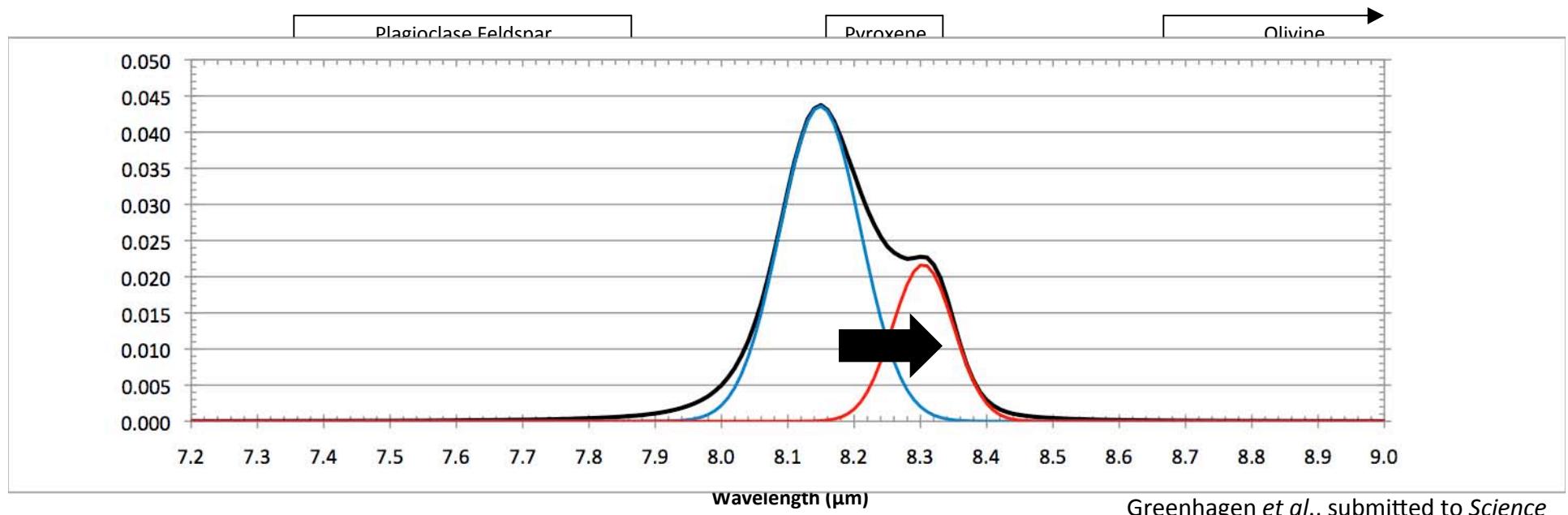
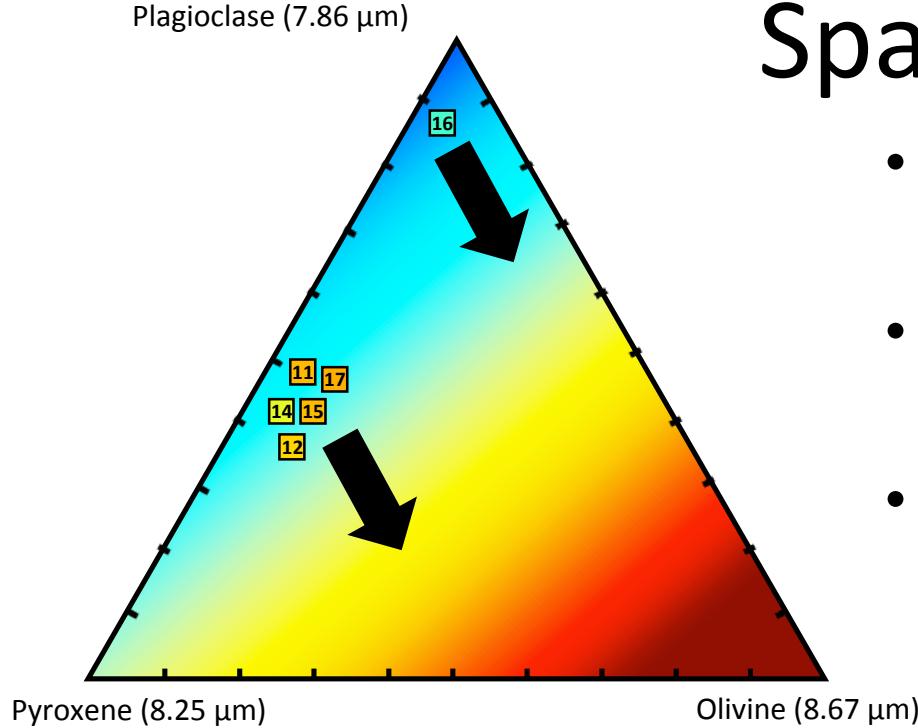
# CF to Composition

- CF shifts to shorter wavelengths with increasing silicate polymerization
- CF position is most sensitive to plagioclase/olivine abundance
- Pyroxene compositions are not unique



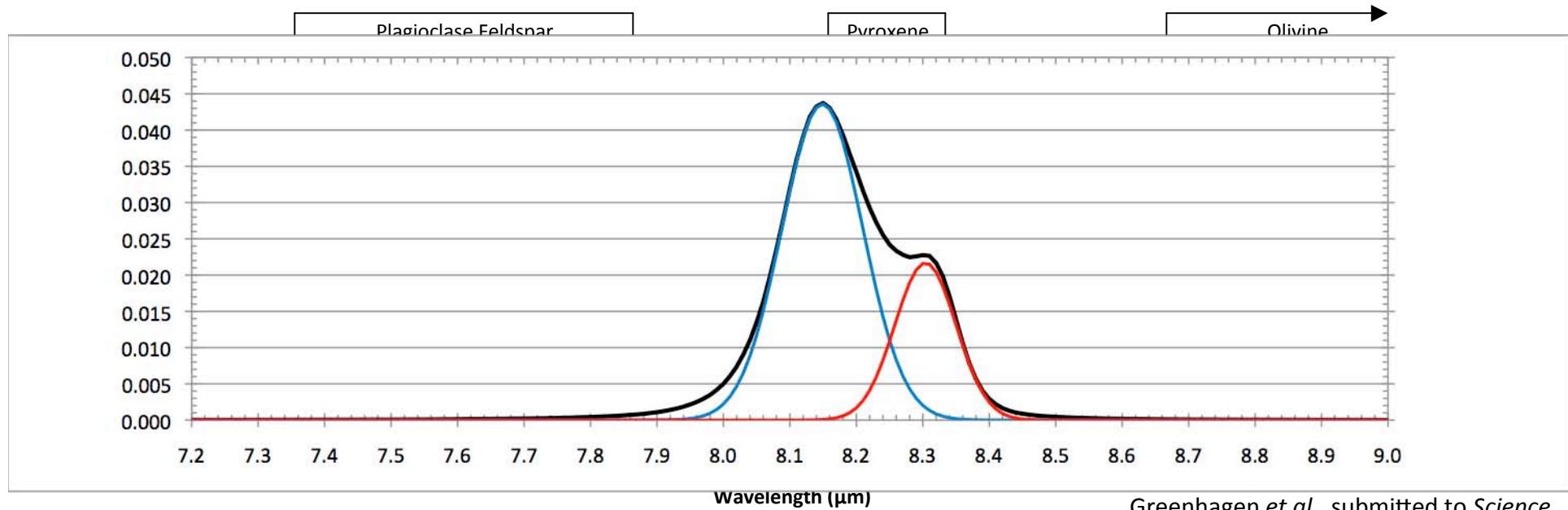
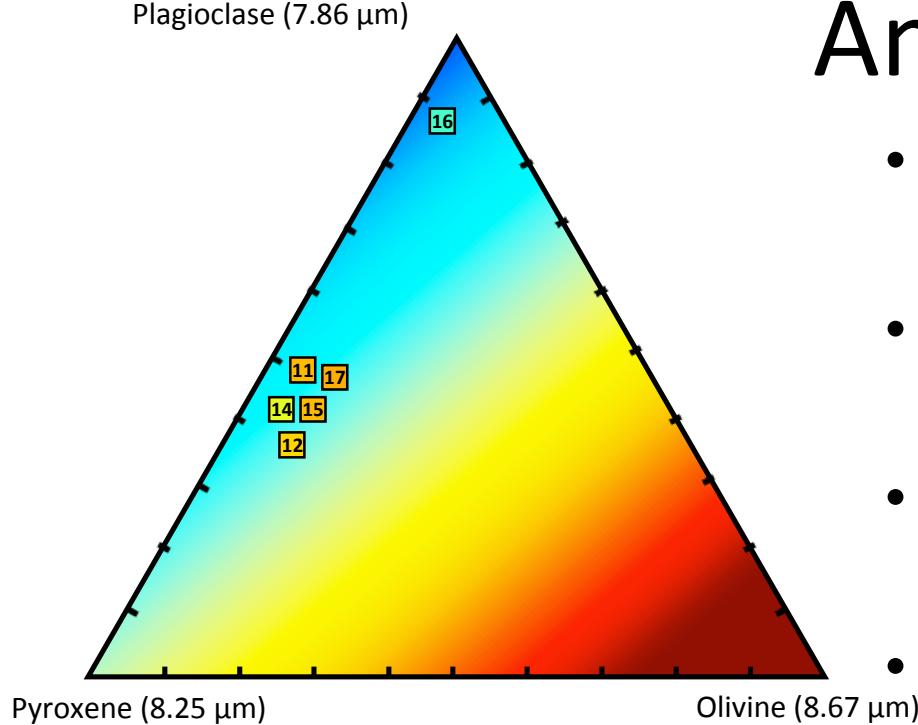
# Space Weathering

- CF shifts to longer wavelengths with increasing maturity
- Increases apparent mafic composition
- Mechanism is not understood – was not predicted in literature

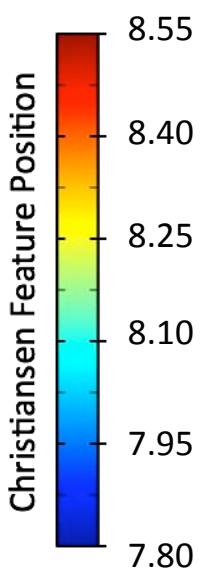
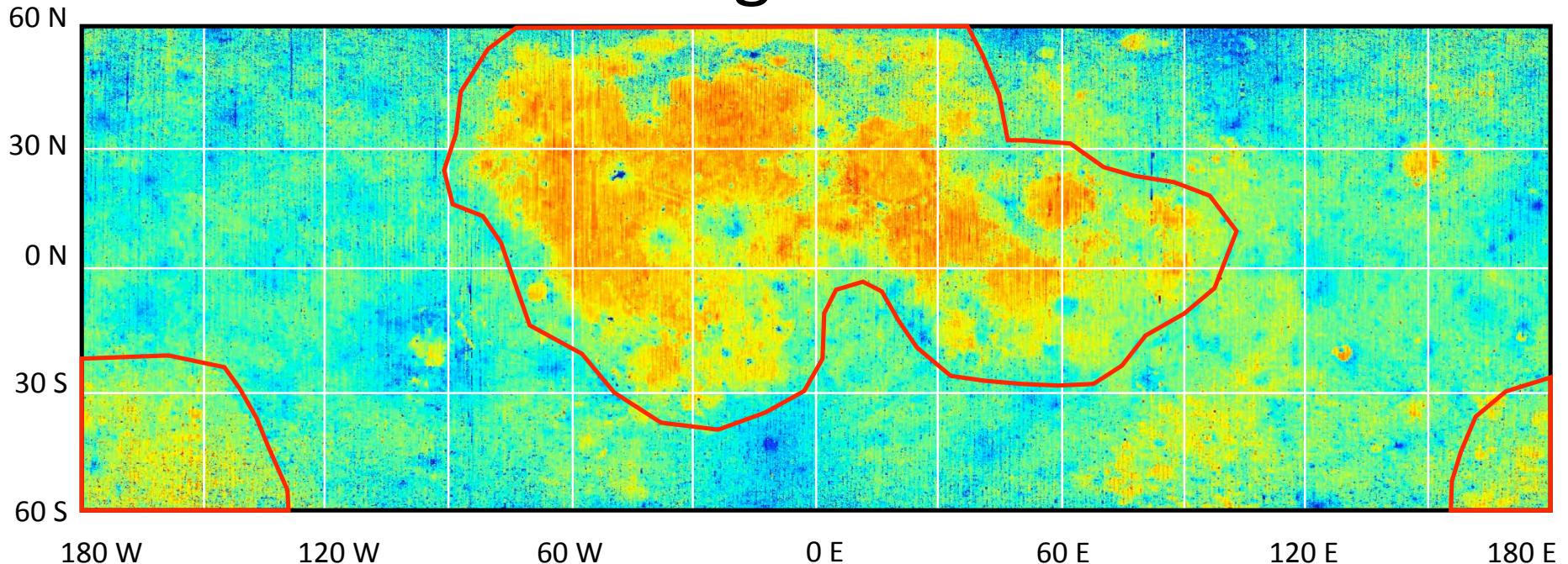


# Anisothermality

- CF shifts to shorter wavelengths with increasing anisothermality
- Increases apparent feldspathic composition
- Caused by roughness-driven topographic shading
- Empirical and spectral corrections

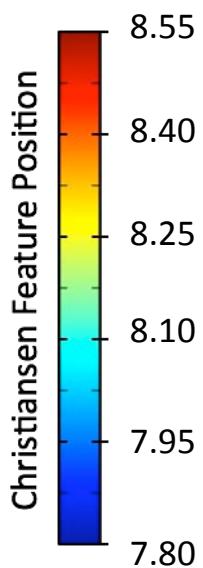
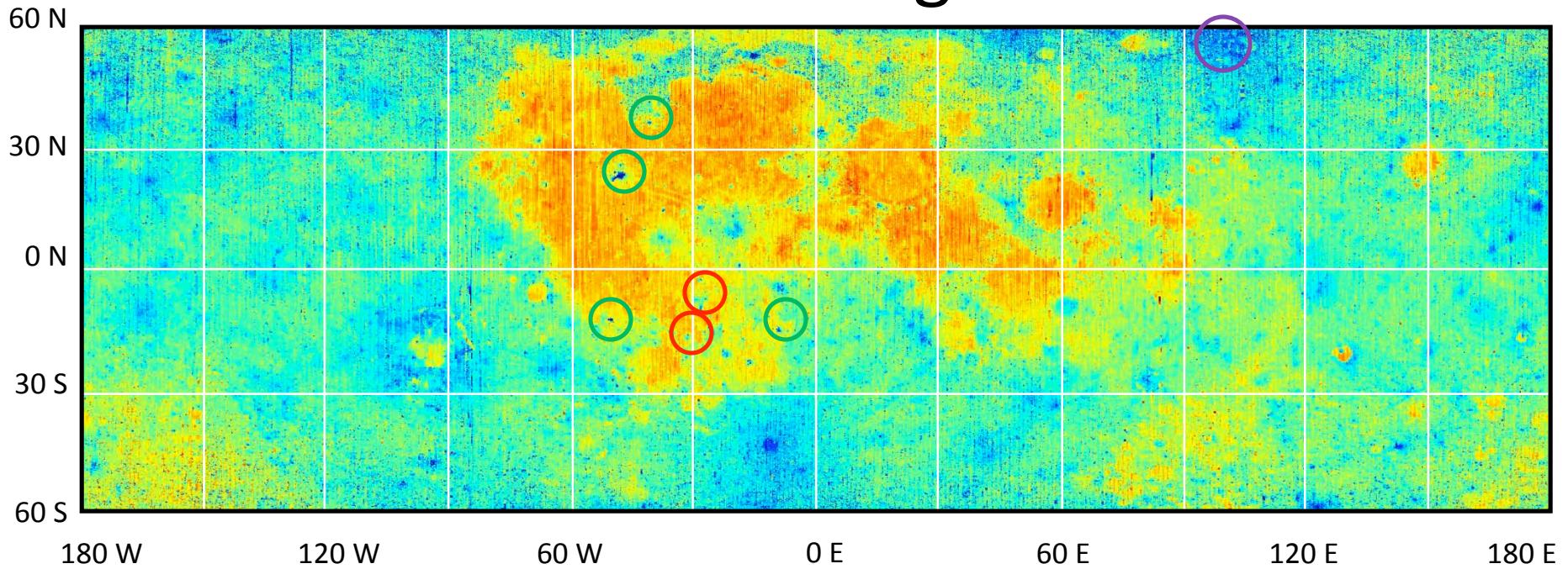


# Maria vs. Highlands vs. SPA



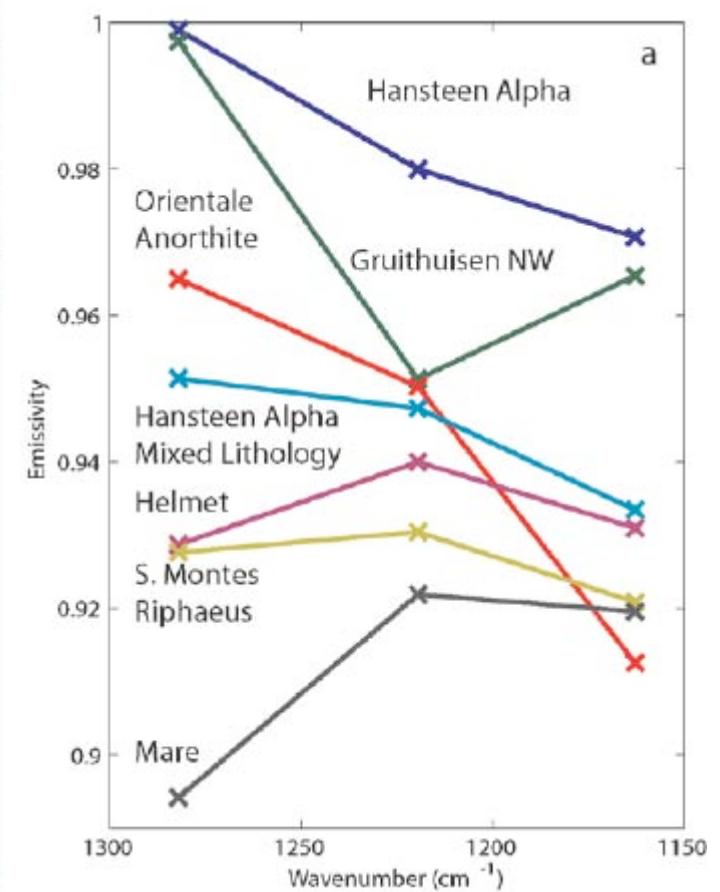
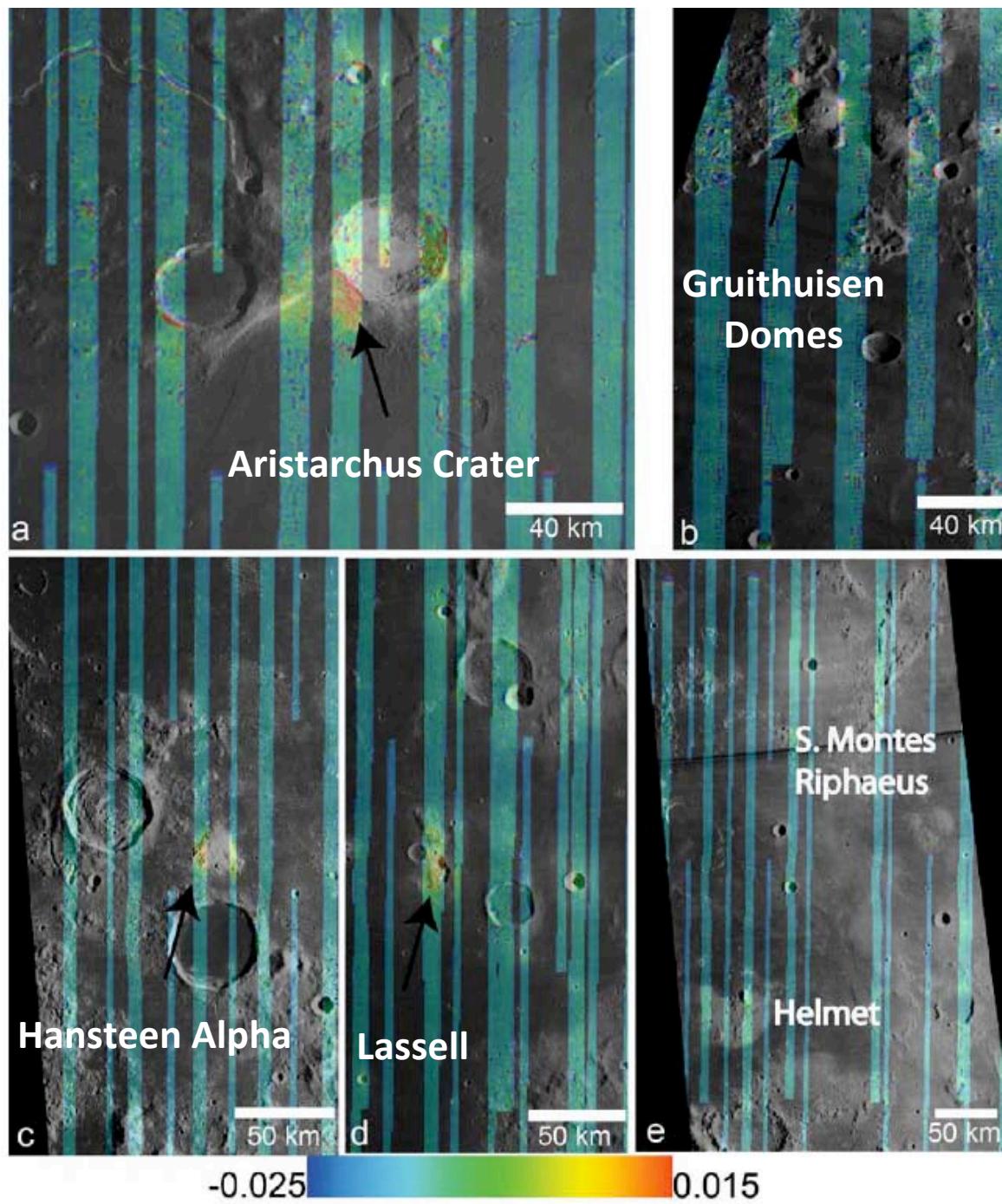
- Highland and mare regions are clearly distinguishable
- South-Pole Aitken basin is intermediate to highlands and maria
- Potentially significant composition variations within highland and maria units
  - Pending removal of space weathering effects

# Silica-rich Regions



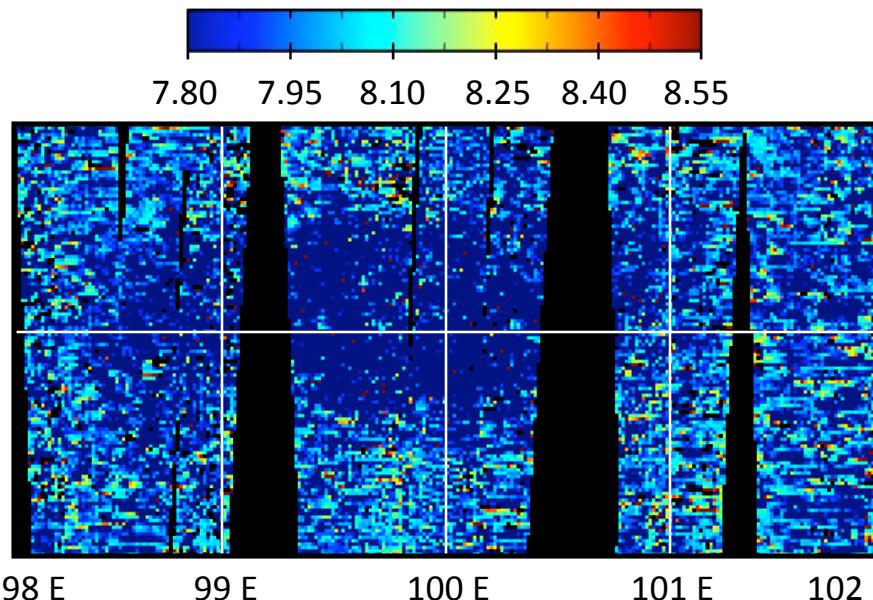
- Areas with high silica content are clearly visible
  - Some but **not all** near side lunar red spots
  - Also the **Compton Belkovich Th anomaly** on the farside

# Lunar Red Spots

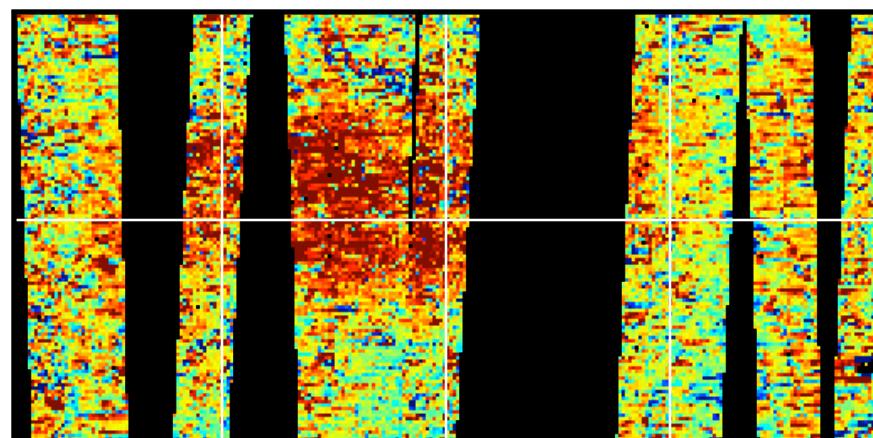
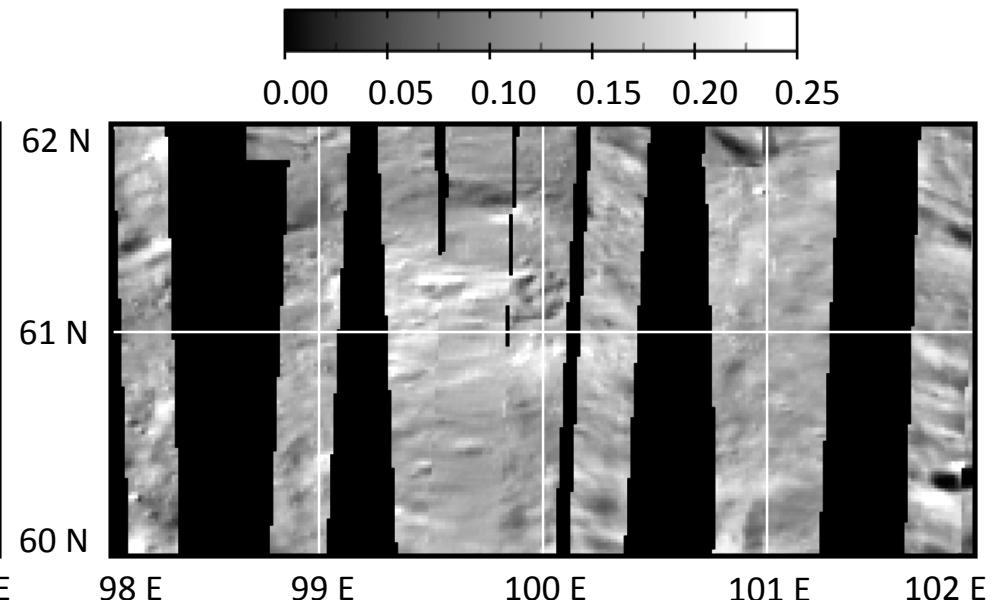


# Compton-Belkovich Thorium Anomaly

Christiansen Feature Position

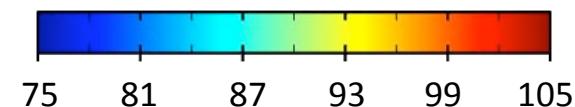


Broadband Solar Albedo

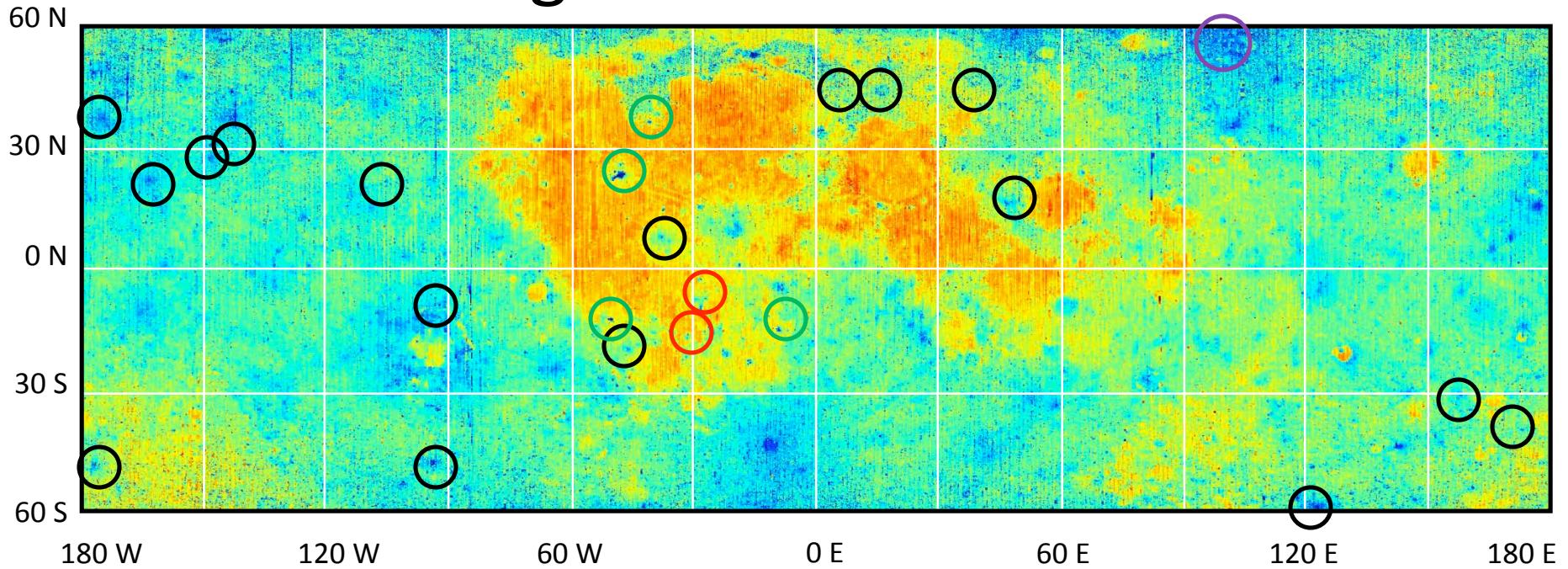


7.81  $\mu\text{m}$  / 8.28  $\mu\text{m}$  Emissivity Ratio

Predawn 26-41  $\mu\text{m}$  Brightness Temp.



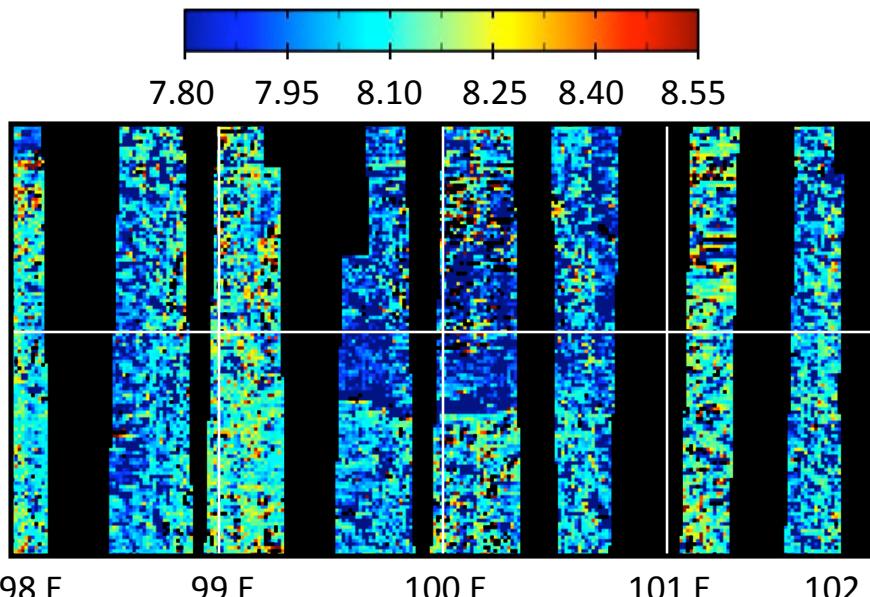
# Plagioclase Anomalies



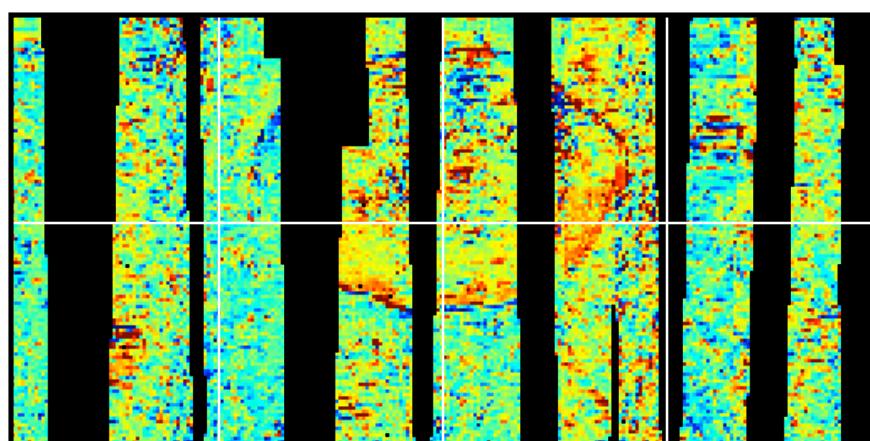
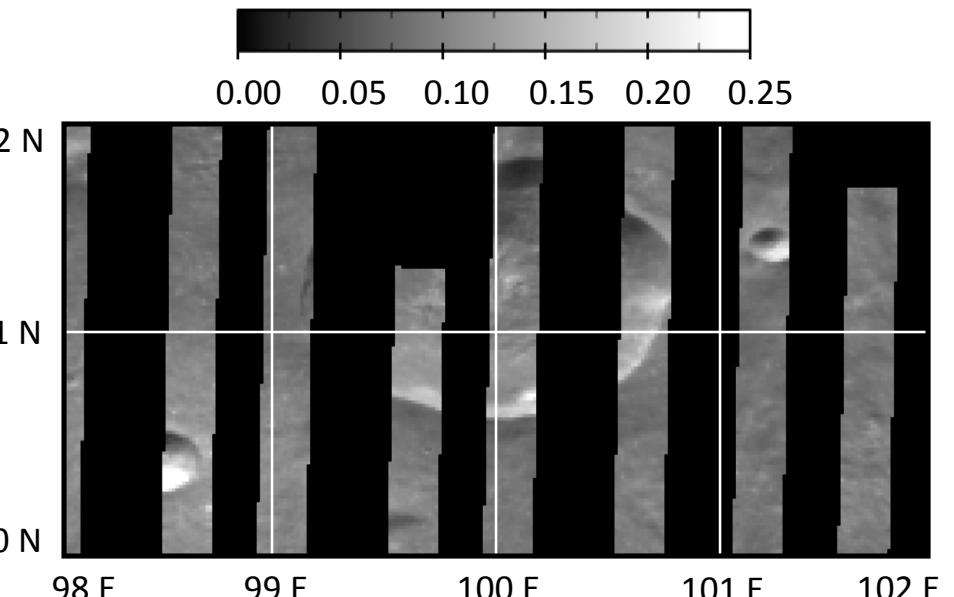
- Areas with high silica content are clearly visible
    - Some but not all near side lunar red spots
    - Also the Compton Belkovich Th anomaly on the farside
  - There are areas with CF positions short of pure anorthite
    - 15 of 69 Ohtake et al. 2009 plagioclase sites show CFs < 7.82  $\mu\text{m}$

# Guthnick Crater (47.7 S, 93.9 W)

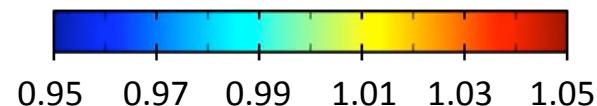
Christiansen Feature Position



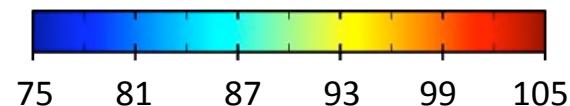
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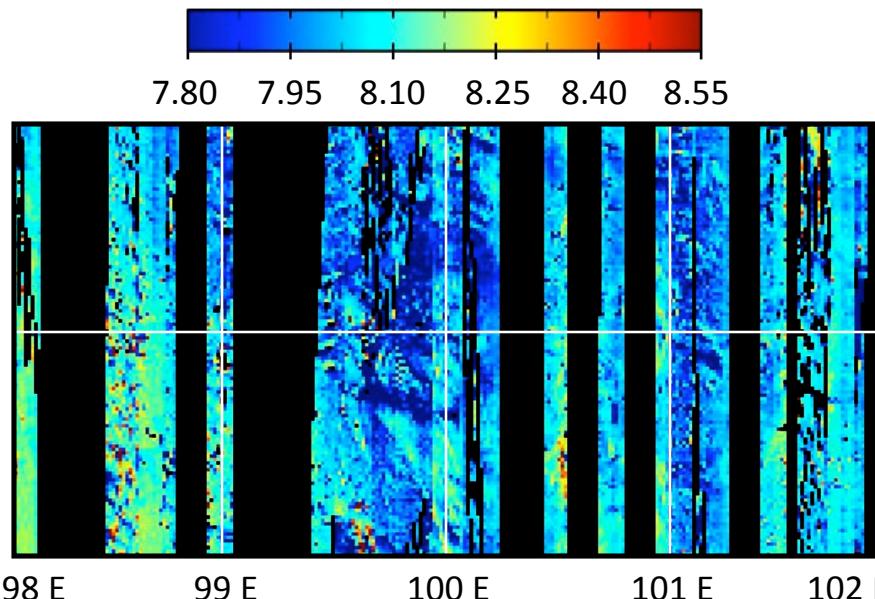


Predawn 26-41  $\mu\text{m}$  Brightness Temp.

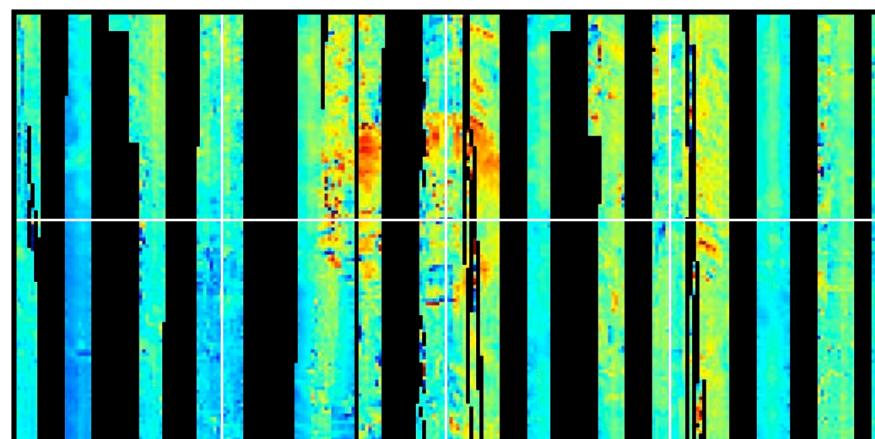
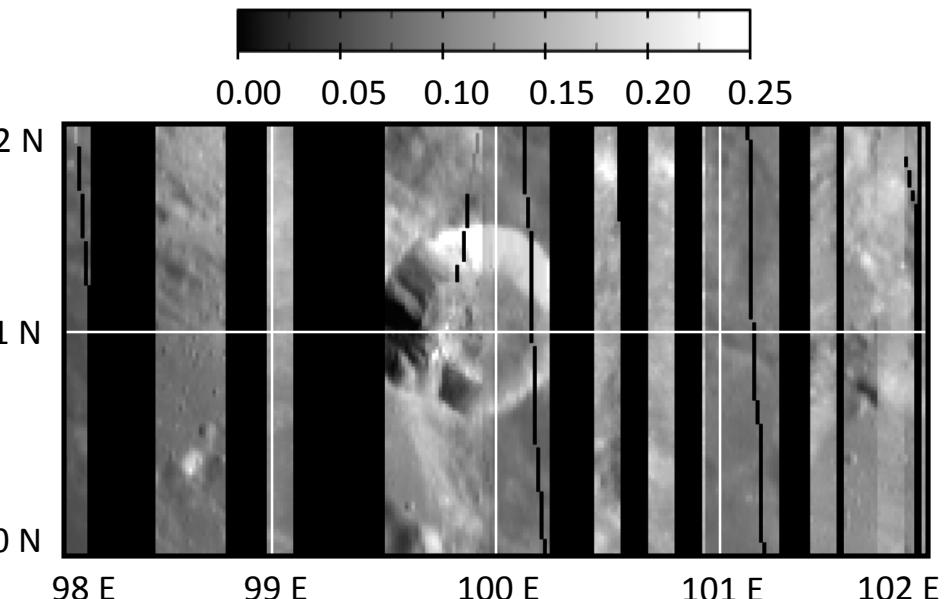


# Proclus Crater (16 N, 46.6 E)

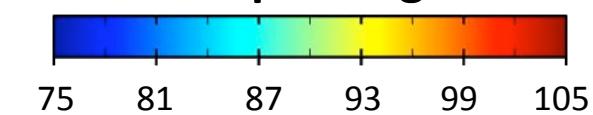
Christiansen Feature Position



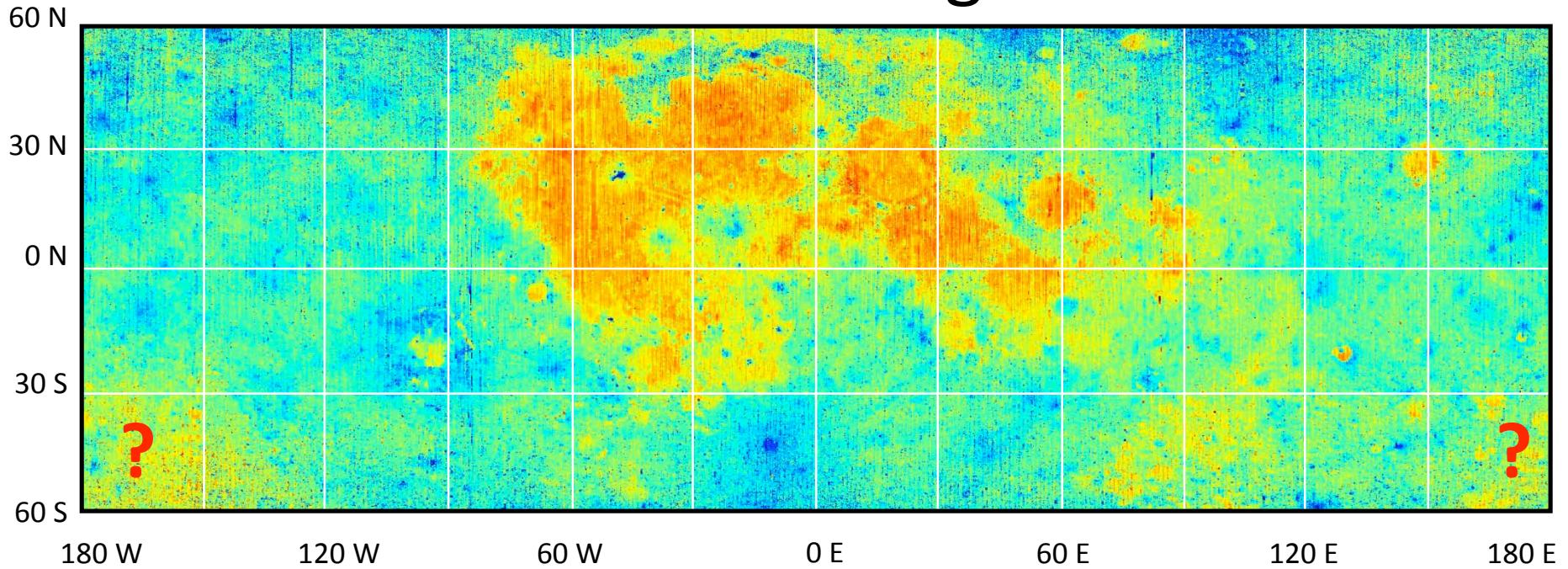
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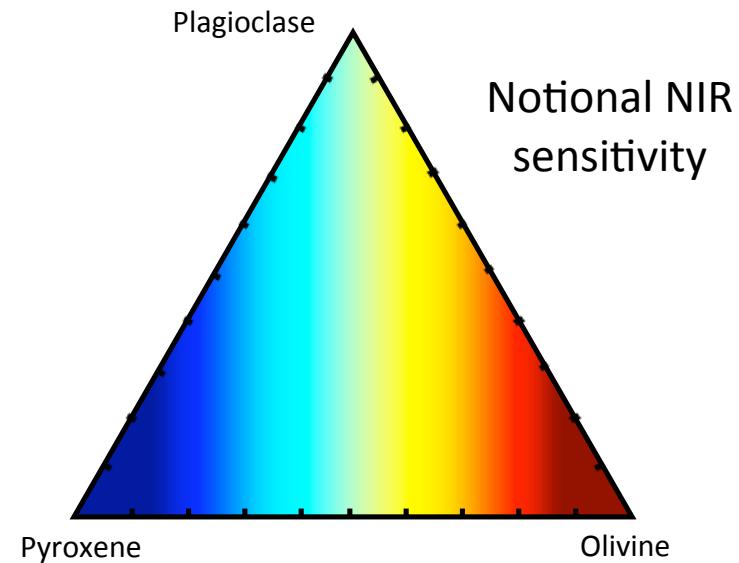
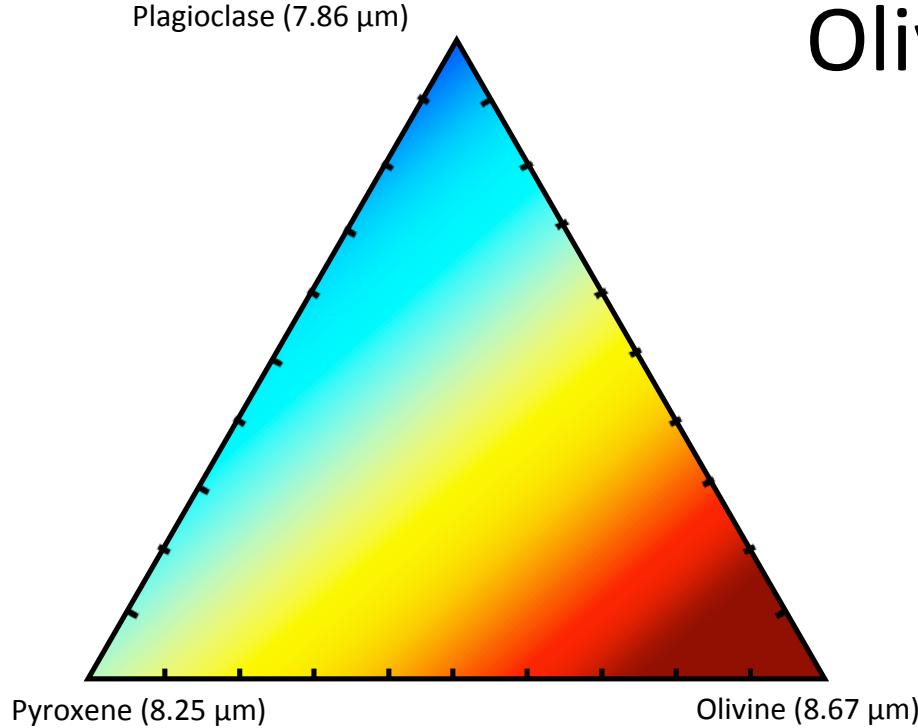


# Olivine-rich Regions



- No evidence for olivine-rich ultramafic mantle (few km scale)
  - Olivine dominated areas should stick out like high silica regions
  - Olivine-rich central peaks do not show CF anomalies
  - There may be some evidence for < 1 km scale exposures in SPA basin
  - Potentially caused by lack of sufficient spatial coverage...
  - But more likely due to significant (> 10%) feldspar abundances

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# Conclusions

- We are observing spectral variations due to composition, space weathering, and anisothermality
  - Variations in highlands/maria composition
  - Regions with high silica and/or alkali/sodic feldspar
  - No exposures of olivine-rich/feldspar-poor ultramafics
- Under construction...
  - Refinement of anisothermality corrections
  - Space weathering corrections
  - Additional simulated lunar environment experiments
- Diviner data and other datasets are highly complementary (e.g. UV/Vis/NIR, Radar, LIDAR)